

WRITTEN TESTIMONY OF

DR. BILL STACY, CHANCELLOR

THE UNIVERSITY OF TENNESSEE AT CHATTANOOGA

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Since its founding in 1886, The University of Tennessee at Chattanooga has been dedicated to providing quality education to a diverse population of over 8,600 students, focusing on the development of excellence in undergraduate education and in selected areas of graduate study. We increasingly strive to provide the best public undergraduate education in Tennessee. Our goal is to assist the economic development and to improve the quality of life for Tennessee and the surrounding region through expansion of its intellectual capital.

The University of Tennessee at Chattanooga's professional and graduate programs are better able to serve our students through the unique assets of the

metropolitan, living laboratory of Chattanooga and surrounding metropolitan clusters. The University of Tennessee at Chattanooga has developed into an excellent Master's Comprehensive I Carnegie institution and is now evolving into distinction as a comprehensive public metropolitan university. The campus "accepts its relationships to the surrounding metropolitan region as its essential rationale, its reason for being," in the words of Daniel Johnson and David Bell in their treatise on this emerging model of higher education institutions.

The purpose of my testimony today is to relate the experiences of The University of Tennessee at Chattanooga in the Next Generation Internet environment, and the challenges we face to achieve full participation in that environment. We are completely aware of the impact high performance networking will have on how we conduct our instructional and research activities in the 21st century, and that some of those activities will undergo profound change. As in the case of many non-Research I institutions, however, The University of Tennessee at Chattanooga does not currently have equitable access to NGI funding, and to the national and regional high performance networking infrastructure, and, thus, is not benefiting from the rich opportunities for collaboration, innovative instructional delivery and resource sharing that the NGI allows. While one goal of the NGI and Internet2 initiatives is to extend the fruits of advanced networking to all levels of educational use, this is far from being a reality today. As documented in the 1999 EDUCAUSE report Advanced Networking for All of Higher Education: "It was noted during a meeting among affiliate members of the Internet2 project late in 1997 that consideration of how the products of these leading edge efforts might 'diffuse' to the broader higher education community-and how to prepare for it-was lacking."

In the absence of a strategy for diffusion, institutions like The University of Tennessee at Chattanooga may have to be content with waiting for the eventual "trickle-down," while most likely having to tolerate the consequences of being on the wrong side of the "digital divide" and the impact that will have on our status and competitiveness. Such a scenario is intolerable to us, and, thus, we are appealing for your consideration of the strategic funding and support that will be necessary to reduce inequities in the NGI environment before those inequities become unassailable.

Simply stated, The University of Tennessee at Chattanooga does not have the financial resources necessary to support campus involvement in NGI/Internet2. In fact, of the more than 700 four-year and two-year universities and colleges in the nine-state Southeastern University Research Association network (including Alabama, Florida, Georgia, Kentucky, Louisiana, Mississippi, North Carolina, South Carolina, and Tennessee) who are eligible for participation in the NGI/Internet2, only 25 institutions are currently members. These numbers clearly show that campuses like The University of Tennessee at Chattanooga have overwhelmingly chosen not to participate. Since the benefits of participation are readily evident, one can assume that non-participation results from prohibitive factors.

For The University of Tennessee at Chattanooga to gain its own access to Internet2/Abilene, membership fees, connector fees, participant fees, and other charges are estimated at \$277,000 for the first year with equal recurring charges in subsequent years. At a time of extremely tight state funding and with the commitment to hold student fees to levels that do not limit accessibility, such costs, even for crucial expenditures, are beyond the reach of most campuses.

Significant problems face campuses that are unable to participate in the NGI/Internet2. As The University of Tennessee at Chattanooga recruits Ph.D.-qualified faculty members, access to networks such as NGI and Internet2 is becoming increasingly important. As doctoral candidates, these faculty members took advantage of the opportunities afforded them by these networks, and their research efforts depend on continued use. The inability of institutions like The University of Tennessee at Chattanooga to provide this high speed access will either deter candidates from joining their faculties or for those who accept positions, their research will be stifled. Similarly, faculty members whose research interests develop on campuses lacking network access may choose to leave for positions where access is available. In either case, the result is a loss of well-qualified faculty members for campuses who lack the resources to maintain network connections.

The University of Tennessee at Chattanooga has increased its emphasis on research, especially applied research that addresses the issues and needs of a metropolitan region. Applied research has more relevance in the educational environment as students can readily see knowledge "applied" to solving real

problems. Likewise, applied research increases the opportunities for partnerships between the campus and the community. Grant funding for NGI/Internet 2 projects does not appear to favor applied research efforts.

Curriculum development and the implementation of new degree programs, especially graduate and doctoral programs, is affected by the lack of access to NGI/Internet2. Student and faculty research will increasingly become dependent-in some fields the need is already absolute-on access to high speed network connections, and campuses that do not have connections will be unable to recruit faculty and students in those disciplines, effectively disabling the program development.

The current fee structure is certainly a deterrent to participation for campuses such as The University of Tennessee at Chattanooga where, at present, perhaps no more than 10 faculty members are engaged in research which could require use of high speed access to computational capabilities. This discounts the possibility of significant research accomplishments by small teams or individuals at regional institutions and instills a bias in the system toward large institutions where a greater number of users would result in high demand for bandwidth.

Despite lack of involvement in high speed access projects, The University of Tennessee at Chattanooga has made great technological strides, especially in its on-campus fiber network. In terms of campus network infrastructure, The University of Tennessee at Chattanooga meets the standard requirement of delivering at least 100 Mbps to the desktop for on-campus traffic; this surpasses the capabilities of many NGI/Internet2 participating campuses.

We may lack the external network connection to access NGI/Internet 2, but The University of Tennessee at Chattanooga does not lack vision and desire for participation. If The University of Tennessee at Chattanooga had access to the NGI/Internet2, the types of research activities which might be advanced include the design of mechanical prostheses, gait analysis, and computational physics, engineering, and chemistry. One faculty member in mathematics studies acoustic models and uses algorithms to detect objects in shallow water. Both the military and oil industry have expressed interest in this research, which is threatened if he does not gain high speed connection. A major insurance company with its headquarters in Chattanooga has worked with a business faculty member to explore new financial models for stock market predictions.

Environmental modeling could include the tracking of pollution in the Tennessee River through partnerships in a water quality research center which includes the Tennessee Valley Authority, the Tennessee Aquarium, and the University of Tennessee at Chattanooga. Chattanooga has received international attention for its successful efforts in air and water pollution control and interest in environmental research is significant both on The University of Tennessee at Chattanooga campus and in the community.

The direct public benefit from expanded access to the NGI for campuses like the University of Tennessee at Chattanooga would be the quicker response to identified needs through applied research results. In a recent address, U.S. Congressman Zach Wamp tied the development of additional graduate and doctoral programs at The University of Tennessee at Chattanooga with the economic vitality and future of Chattanooga and the surrounding area. Jim Kennedy, president of the Chattanooga Area Chamber of Commerce echoes Wamp's sentiment. "Chattanooga is a city that has reinvented itself," said Kennedy, "and we are in the midst of a strategic planning process-the success of which will hinge in large part on The University of Tennessee at Chattanooga's ability to deliver on applied research. Moreover, the change in technical training required of college graduates underscores the need for a well-wired university."

In comparison to The University of Tennessee at Chattanooga's experiences, I would like to illustrate what NGI participation and federal support can enable by describing the experiences of The University of Tennessee, the flagship institution of The University of Tennessee System in Knoxville. I hope my illustration will demonstrate what the NGI is enabling now in some reaches of higher education, and what the NGI will enable in future, once the challenges to full exploitation of NGI resources are overcome. Most significantly, I hope this illustration will serve to elucidate what benefits institutions like The University of Tennessee at Chattanooga are being deprived of in our current exclusion from the NGI.

A charter member of Internet2, The University of Tennessee was the recipient in 1997 of an NSF High Performance Connections grant (\$350k) to fund connection to the very High Performance Backbone Network Services (vBNS) national backbone. Since February 1999, UT has accessed the vBNS via the

regional GigaPOP at The Georgia Institute of Technology in Atlanta with a 45Mbps. (DS-3) connection, and has also connected to the regional Southeastern Universities Research Association network, Southern Crossroads, via the GIT GigaPOP.

Currently, both the Knoxville and Memphis University of Tennessee sites are preparing to migrate to Abilene, the Internet2 gigabit backbone. With the relaxation of the Abilene conditions-of-use in 1999, primary Abilene participants are now in a position to sponsor secondary participants, once meritorious use is demonstrated. Organizations, such as libraries, museums, K12, and institutions such as The University of Tennessee at Chattanooga, who would not otherwise enjoy Abilene access, are now presented with that opportunity. We anticipate this very encouraging development will foster more pervasive access to the NGI and should generate some very fruitful outcomes.

In addition to High Performance Connections program funding, The University of Tennessee was jointly awarded \$6.5m in 1998 by the NSF and the Ministry for Science and Technology of the Russian Federation for the MIRNet project - to provide Next Generation Internet services to collaborating US-Russian scientists and educators. The goals of the MIRNet project include assisting meritorious scientific collaborations requiring advanced, high performance internet services; connecting the Russian Next Generation Internet network to the US vBNS, and other next generation networks in the US and elsewhere; and, more broadly, encouraging and supporting productive cooperation between the US and Russian scientific communities.

The University of Tennessee, therefore, by virtue of its Carnegie I status, and its demonstrated need for high performance network connectivity, has been able to successfully compete for federal agency support, and has thus been enabled to fully participate in the NGI efforts being pursued under the aegis of Internet2, a consortium of over 170 U.S. research institutions, government, and over 50 industry partners.

With the enabling network infrastructure in place, The University of Tennessee has been positioned to pursue and secure additional funding, including awards from The Southeastern Universities Research Association for development and promotion of next generation video-over-IP technologies; from The NSF Knowledge & Distributed Intelligence (KDI) program for development of interactive, online supercomputing training modules; and from The NSF for a

Scalable Intracampus Research Grid (SInRG) project for the deployment of a research grid on The University of Tennessee campus at Knoxville, mirroring the technologies and the interdisciplinary research collaborations that are characteristic of the emerging national technology grid.

Like many of the 100 research institutions awarded grants in the NSF High Performance Connections program, The University of Tennessee is faced with challenges to optimal use of its advanced networking capabilities. The challenges include last mile or local loop problems, i.e., the quality of the connection to the end user's desktop, and the need for campus networking upgrades, the characteristically high cost of high performance applications and the lack of funding for application development, the high demands on faculty time and lack of incentive to develop applications, the need for advanced middleware and resolution of network performance issues. Next generation internetworking in general, is still essentially a testbed environment, with network engineering issues, such as Quality-of-Service, yet to be resolved. Many of the technologies that can realize the benefits of broadband networks are emerging, and thus can suffer from poor interoperability, lack of standardization, and high cost.

The dearth of traffic and applications taking advantage of the advanced research network infrastructure is a cause for concern nationally, which, not surprisingly, has resulted in a reevaluation of the merits of funding infrastructure. Universities, such as The University of Tennessee at Chattanooga, which have not already received infrastructure funding, therefore, will likely find making a case to do so difficult. The NSF Division of Advanced Networking Infrastructure and Research has now recognized the need to support end-to-end application development through funding of advanced network services, and has concluded that direction and support in this area is vital for full utilization of our NGI resources to be realized. This conclusion has been fully endorsed in the Internet2 community. Certainly, although there is disappointment with the current state of application development, the essential infrastructure is now in place, thanks to federal agency support. It is critical that disappointment does not lead to this support being abandoned and a loss of momentum; continuing support will serve to enable us to exploit achievements to date and realize the full potential of the NGI.

While The University of Tennessee, like many of its peers, has faced challenges to application development, it has still been in a position to reap other benefits of membership in the NGI/Internet2 community. Some of the benefits of NGI

participation are obvious-access to collaborative tools, remote virtual environments, remote instrumentation, distributed computing resources, and digital libraries, for example. However, as Research-1 institutions coalesce around the NGI/Internet2 focus, additional and equally significant benefits for their Information Technology organizations and constituencies have emerged-sharing of resources and expertise, development of a skilled IT workforce, emergence of multi-institutional partnerships and collaborations, and the leveraging of these partnerships towards more effective relationships with industry and the vendor community, and the opportunity to contribute to the design and implementation of the NGI.

The University of Tennessee has made good use of these membership advantages, and has demonstrated leadership in NGI/Internet2 in initiating and fostering multi-institutional collaborations, such as The Video Development Initiative, a multi-institutional effort to promote the deployment of digital video in higher education, and the Internet2 Distributed Storage Infrastructure (I2-DSI), a replicated hosting service for Internet content and applications. The University of Tennessee Health Science Center in Memphis is an active member of the "Early Harvest" Internet2 initiative which seeks to provide privacy, authentication and authorization tools to support medical applications. The Health Science Center and The University of Tennessee College of Veterinary Medicine are also participating in a new Health Sciences initiative sponsored by Internet2.

The University of Tennessee is currently endeavoring to leverage its own resources, and the collective resources it now has access to, towards application development. Brief descriptions of some of the applications underway at The University of Tennessee illustrate how NGI-enabled applications can enrich instruction and research.

Virtual Rounds is an application at The University of Tennessee College of Veterinary Medicine that entails the sharing of live animal clinical caseloads with the colleges of veterinary medicine in the southeast. Geographical obstacles have previously restricted veterinary teaching hospitals from sharing caseloads, but by taking turns at presenting live cases via high-quality teleconferences, the participating colleges can not only increase the number and variety of live animal cases their students are exposed to, but can also benefit from interaction with their peers. Sharing of clinical cases is the first step in the exploitation of emerging technologies and NGI capabilities for the

sharing
of resources and for collaboration in veterinary medical education.

Since 1995, the Radiology Department at The University of Tennessee Health Science Center in Memphis has utilized remote directed abdominal ultrasound, with a radiologist at a central site monitoring and directing ultrasound studies

being actually performed by trained technologists at various sites throughout Memphis and West Tennessee. While one of these studies can be relatively easily accommodated on commodity telecommunications links, abdominal ultrasound is only one of many radiology studies which itself is a subset of other

medical procedures. To mature from a niche application to comprehensive remote delivery of patient procedures will require significant additional aggregate bandwidth. In addition, The University of Tennessee Health Science Center operates training programs and has numerous clinical interactions at many sites, including Jackson, Dyersburg, Nashville, Knoxville and Chattanooga, while The School of Nursing in Memphis offers graduate degrees entirely over the Internet. However, with the congestion on today's commodity Internet, there are limitations to the scale and degree of interactivity achieved.

The health sciences arena is one that is likely to be greatly impacted by the NGI,

but application developments are still in their infancy and much of the promise remains to be tapped. The National Institute of Health has been a strong advocate of the NGI but support for grass-root efforts and an ubiquitous high speed networking infrastructure for use in telemedicine, medical research and distance education applications is critical. With the enabling infrastructure in

place, for example, The University of Tennessee at Chattanooga would be able to access the large gene databases located at the Department of Energy and other sites to support its participation in the human and mouse genome projects, and enhance its offerings in biological science education.

The University of Tennessee is partnering with regional and national networking organizations (The National Laboratory for Applied Network Research (NLNR), the National Center for Atmospheric Research (NCAR) and the Pittsburgh Supercomputing Center) to work towards a solution to the poor performance of large file transfer. The short-term goal is to meet the immediate

demand at The University of Tennessee for large data transfer, demand from faculty/researchers in High Energy Physics, and Computer Sciences, for

example. Over the long-term, the envisioned goal of this project, called Web100, is to arrive at improved performance in commercial host software in general in order to fully avail of bandwidth.

The University of Tennessee has recently accelerated its application development, and is also planning additional applications, including the development of virtual design studios for use in architectural instruction and research, the creation of high-quality on-demand live and archived digital video assets for use in all disciplines, digital library development, and the fostering of collaborative opportunities through the development of a high-quality teleconferencing-over-IP service.

Finally, with the recent award to The University of Tennessee and Battelle partnership of the management contract for The Oak Ridge National Laboratory, The University of Tennessee, Oak Ridge Associated Universities (Duke University, Florida State University, Georgia Institute of Technology, North Carolina State University, University of Virginia and Virginia Tech), and The Department of Energy will now be able to pool and leverage NGI resources and expertise towards supporting and fostering excellence in areas such as neutron science, distributed computing, biotechnology and advanced materials, and network research.

"Advanced Networking for All of Higher Education: Recommendations and Report from the Institutional Opportunities for Advanced Networking" Net@EDU Conference, January 1999, Austin, Texas: p. 7.

CONCLUSIONS

In conclusion, I hope my testimony demonstrates the eagerness of The University of Tennessee at Chattanooga to participate in the NGI/Internet2. I hope that I have also shown that funding for enabling infrastructure is just the beginning, and much more can be achieved if federal agency support continues. One recommendation would be to change the Internet2 fee structure to allow levels of membership based on an institution's expected use of the network. Current network use does not even come close to exceeding bandwidth limits, and the benefits gained from expanded access to campuses like The University of Tennessee at Chattanooga are far greater than the risk of system overload.

The higher educational community is just starting to witness the first fruits of the NGI, but already there is ample evidence of the contribution the NGI is likely to make to successfully fulfill our research, instruction and public service missions in the 21st Century.

In closing I would like to leave you with this. The steel rails used to deliver goods and information in the past have been replaced by miles of electronic fiber. Since the fiber network largely follows the rail lines, the University of Tennessee at Chattanooga is well situated geographically to access the fiber networks necessary for NGI and Internet2 use. The dream of a Tennessee Technological Corridor running from Knoxville to Oak Ridge to Chattanooga will not be a reality until The University of Tennessee at Chattanooga is afforded participation in the NGI and Internet2. Oak Ridge, Tennessee, well known as a major computational center, is only 90 miles from Chattanooga; however, it may as well be across the country because of The University of Tennessee at Chattanooga's inability to access it through a high speed network. Please help us bridge that 90 miles, and we guarantee the investment will be multiplied in return.